NORFRA

E.I.A. NORFRA

DUTCH SECTOR

NOVEMBER 1996

Preface

According to Statoils corporate policy and guidelines on health, environment and safety (K/KR-17) Statoil shall in all activities predict risks of detrimental environmental impacts, and assess the environmental consequences of plans, activities and products. This Environmental Impact Assessment report on the NorFra-pipeline through Dutch sector has been prepared with reference to these policy statements and guidelines.

A Dutch consultancy (Oranjewoud) has produced a background documentation on fishresources and fisheries in the Dutch sector ("NorFra Pipeline, documentation on fish resources and fisheries in the Dutch sector of the North Sea", Oranjewoud 1996). Additional information and experience from pipeline projects and different strudies both in Norway, Germany and France have been used as additional references.

Summary

Possible effects as a result of the construction and operation of the NorFra-pipeline are mainly related to:

- effects on the environment (intervention works/trenching, emissions, discharges)
- effects on the fisheries

• Possible effects on the environment

The commissioning includes discharge of seawater containing some chemicals. The discharge will only take place at 10-20 m. depth in the Norwegian sector (Draupner E platform). Compared to similar operations some years ago, the use of chemicals is substantially reduced and no impact on the environment is expected. No discharge is planned in the Dutch sector. Commissioning also includes emission of CO_2 and NO_X into the air. This will take place in the Dunkerque-area in France.

Emission from pipelaying vessels and other vessels to be used during construction (NO_X, SO2, and CO2) is estimated. The NO_X emission from the vessels to be used is estimated to 700 - 1.050 tons, which is comparable to emissions from similar activities.

An eventual damage of the pipeline will cause emission to the atmosphere (mainly methane), but the probability of such an accident is extremely low. An accidental emission of gas will hardly have any impacts on marine life.

Geotechnical and morphological surveys has been carried out along the pipeline corridor. The conclusion is that the pipeline will have no significant negative effect on the morphology along the route.

The construction/laying of the pipeline will only cause local disturbances on the seabed along the corridor, and the impact on the local fauna will only be of a temporary kind.

The NorFra pipeline crosses the Klaverbank, one of the areas defined as a environmental sensitive zone. Although the Klaverbank is an area with special protections, there are no restrictions with respect to the laying and use of offshore pipeline.

A total assessment indicates that the environmental impacts from the to construction and operation of the NorFra-pipeline will be insignificant. Impacts on the marine environment are expected to be limited both in time and space.

• Possible effects on fisheries

Possible impacts on the fish resources and fisheries are related to construction/laying and the actual presence of the pipeline, discharge of contaminated seawater (in the commissioning phase) and a possible accidental outlet of gas.

An accidental outlet of gas will cause only temporary and very local effects.

During the construction period the influenced area in the pipeline corridor will be restricted for fisheries. These restrictions are temporary and local.

Fishery authorities and representatives of the fishing organisations have focused on potential problems related to pipelines and trawling. Documentation on these issues have become better over the last years. Trawling over large pipelines have been tested out both in Norway (1995), Germany (1995) and the Netherlands. The main conclusions from all these test are that fishing/trawling are not hampered by a pipeline similar to NorFra's dimensions. However, there exists little documentation on large parallel pipelines like Zeepipe and NorFra and their impact on trawling. Norwegian fishery authorities' policy on this point is to construct/lay pipelines as parallel and close as possible. As the pipeline will we trenched in most of the Duch sector (more than 90%), the potential problems of crossing the pipeline with trawls should anyway be minimal.

Generally the overall assessment of problems related to the fisheries and the existence of the NorFra-pipeline concludes that no major negative impacts are expected.

1 Introduction

1.1 General

NorFra project is a pipeline for transportation of natural gas from the Norwegian gasfields (offshore connecting platform is Draupner E) to an onshore gas receiving installation in Dunkerque in France, a total of some 863 km.

The pipeline will run across dutch sector for some 467 km (see fig. 1.1).

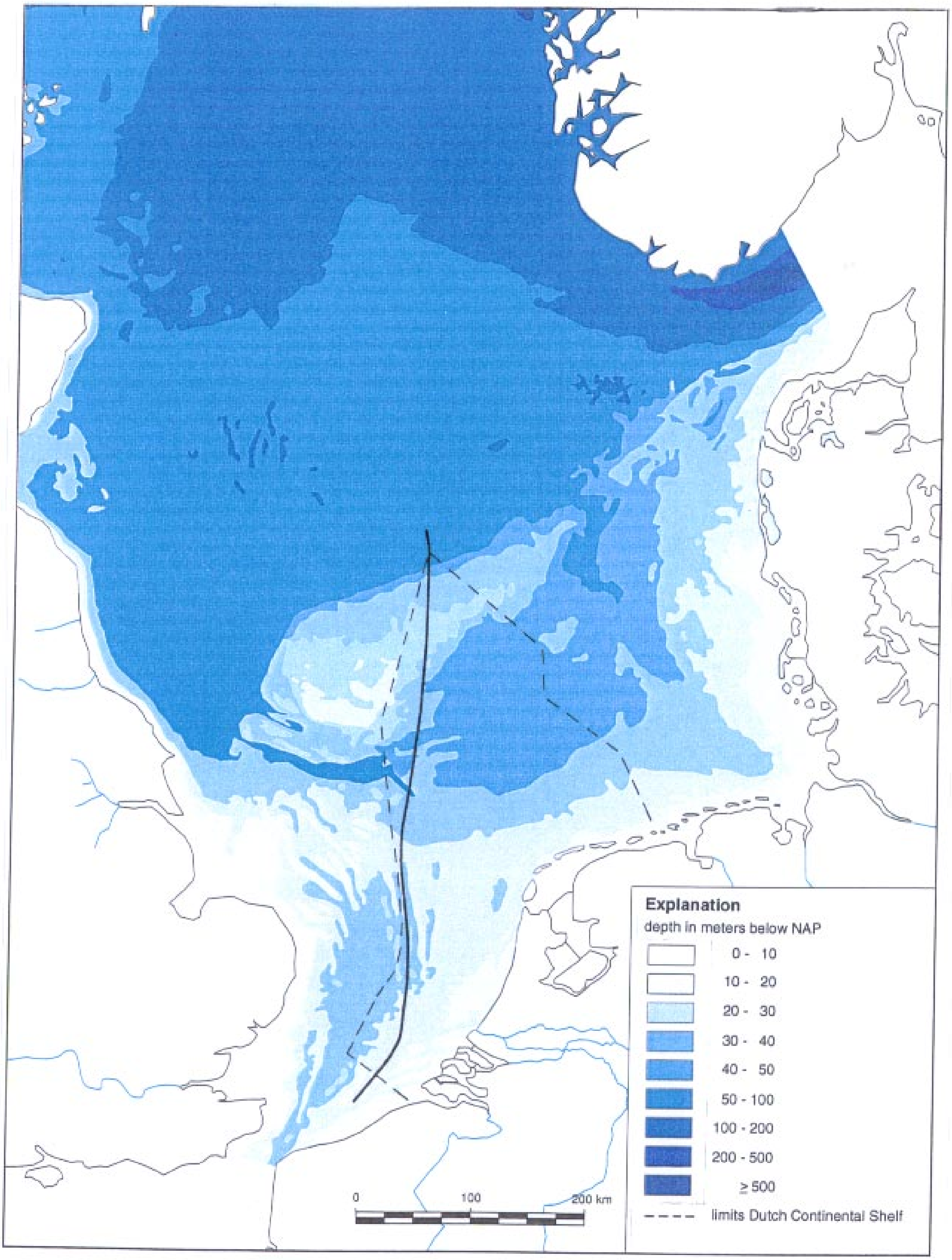
1.2 Partners

The partners in the pipeline project are:

- The Norwegian state oil company (Statoil)	53.2 %
- Norwegian Hydro Prod. a.s	10.0 %
- Saga Petroleum a.s	8.0 %
- Esso Exploration and Production Norway A.S	6.0 %
- Mobil Development A.S	6.0 %
- TOTAL Norway A.S	4.5 %
- Elf Petroleum Norway A.S	3.3 %
- Norwegian Agip A.S	3.0 %
- Norwegian Shell	2.0 %
- Neste Petroleum A.S	2.0 %
- Norwegian Conoco A.S	2.0 %

Statoil is the operator of the project.

Figure 1.1: The NorFra pipeline route in the Dutch sector of the North Sea, including the depth of the areas crossed (source map ICONA, 1992)



2 Project description

2.1 Dimensions, capacities, pressure

The dimension of the NorFra pipeline will be 42". The pipeline will have a transport capacity of approximately 50 mill. Sm^3 natural-gass/day (MSm^3/d) at an inlet pressure of 155 barg.

The gas transported by the pipeline system will be dry in accordance with the sales specifications.

2.2 Pipeline corridor

The total length of the pipeline is approx. 863 km. About half of the distance, 467 km, is in the Dutch sector. The water depth varies from approx. 70 m near the Draupner E platform, while it is 25-40 m in the Dutch sector. Detailes concerning the route and profile are given in the document "Route general layout - 2nd laying season (DO54-A-P111-F-XR-010).

2.3 Seabed

From a geotchnical point of view the route is relatively homogeneous, mainly sand. In some areas there are sand waves. Surface clay (soft to medium stiff) is present from KP 494 to KP 527. Detailed soil information is included in the report "Geotchnical design parameters" (DO54-A-P111-A-RE-003).

2.4 The pipeline

The steel pipes will first be covered with corrosive inhibiting asphalt, then the pipes will be coated with concrete (88-110 mm).

The planned technical lifetime for the pipeline is estimated to min. 50 years.

2.5 Laying of pipeline

The laying of the pipeline will be done by large laying vessels. The actual laying will take place in 1997. Before laying of the pipeline the sea bottom will be levelled by pre-sweeping. Pre-sweeping in the sandwave areas will be limited to the upper sand layers, and is generally limited to the sandwave crests. Pre-sweeping depths are generally less than 2-3 m, but can occasionally reach 4 m in the sandwave areas. In the Approach Area to Eurochannel (KP 707.26 - 712.41), pre-sweeping depth may reach down to a maximum of 6 m. Also in this area the sediments to be pre-sweeped are supposed to be sand. Handling of pre-sweeped material is to be agreed with the authorities, but it is generally foreseen that the pre-sweeped material can be placed along the pipeline route, except in the shipping channels. The total pre-sweeping material in the Aproach Area to the Eurochannel is calculated to 105.000 m^3. The pipeline will for stability reasons be trenched in most of the Duch sector (more than 0.5OD along more than 90% of the lenght) after pipelaying. A combination of hydrolic jetting and ploughing will be used for trenching. Further details are given in the document "Definition of pipeline lowering criteria" (DO54-A-P111-F-RE-010). Lowering requirements are summarized in the in fig. 3.2.

2.6 Pipeline and cables

The NorFra pipeline will cross or be layed close to existing pipelines and cables in the area. It will run parallell to the existing Zeepipe I for about 438 km, with a nominal seperation ranging from 50m (north of the sandwaves) up to 75m and 85m (sandwave area).

Crossing of the existing pipelines/cables will be achieved by means of separation gravel berms dumped on top of the system to be crossed. After laying, the NorFra pipeline shall be covered by post-lay gravel dumping. Typical gravel size is D_{50}=75mm.

These existing pipelines and cables are shown in table 2.1.

Table 2.1: Existing pipelines and cables

Westgastransport Extension Markham J6A Noordwinning K13-A	NL	Pipe line	Wintershall (operator)	1992	24" GAS	The gas pipeline is crossing above Zeepipe I
UK-Germany no. 5 Winterton-Juist	NL	Cable	BTI and co-owners	1991	50 mm	
UK - NL no. 14 Winterton - Egmond	NL	Cable		Planned 1996		
Zeepipe I Sleipner A - Zeebrugge	NL	Pipe line	Statoil (operator)	1992	40" GAS	
UK - NL no. 12 Aldeburgh - Domburg	NL	Cable	BTI/NPTT	1989		

2.7 Subsea TEEs

Two 24" subsea TEEs are planned to be installed along the NorFra route. Indicative locations are at KP 590 and KP 726. The TEEs consist of welded full encircled sleeve branches. A protectio shroud will be installed on each TEE. The hight of the TEE including the protection shroud will be approximately 0.5m refered to top of the pipeline. The TEEs and protection shroud will be covered with gravel or trenched below the seabed.

2.8 Shipping lanes

The pipeline will cross different shipping lanes as shown in fig. 2.1. The ship traffic in this area is substantial. The crossing of the shipping lanes may require special measures in order to protect the pipeline. Further details on crossing of the shippinglanes with the relevant pipeline lowering criteria are given in the document "Basic design data and criteria for detail engeneering - Offshore and landfall pipeline" (DO54-A-P111-A-RE-001).

2.9 Costs

Estimated costs are approx. 9 mia. 1994 NOK The pipeline itself will cost approx. 7 mia NOK.afety Special safety studies have been carried out as an important part in the planning of the project.

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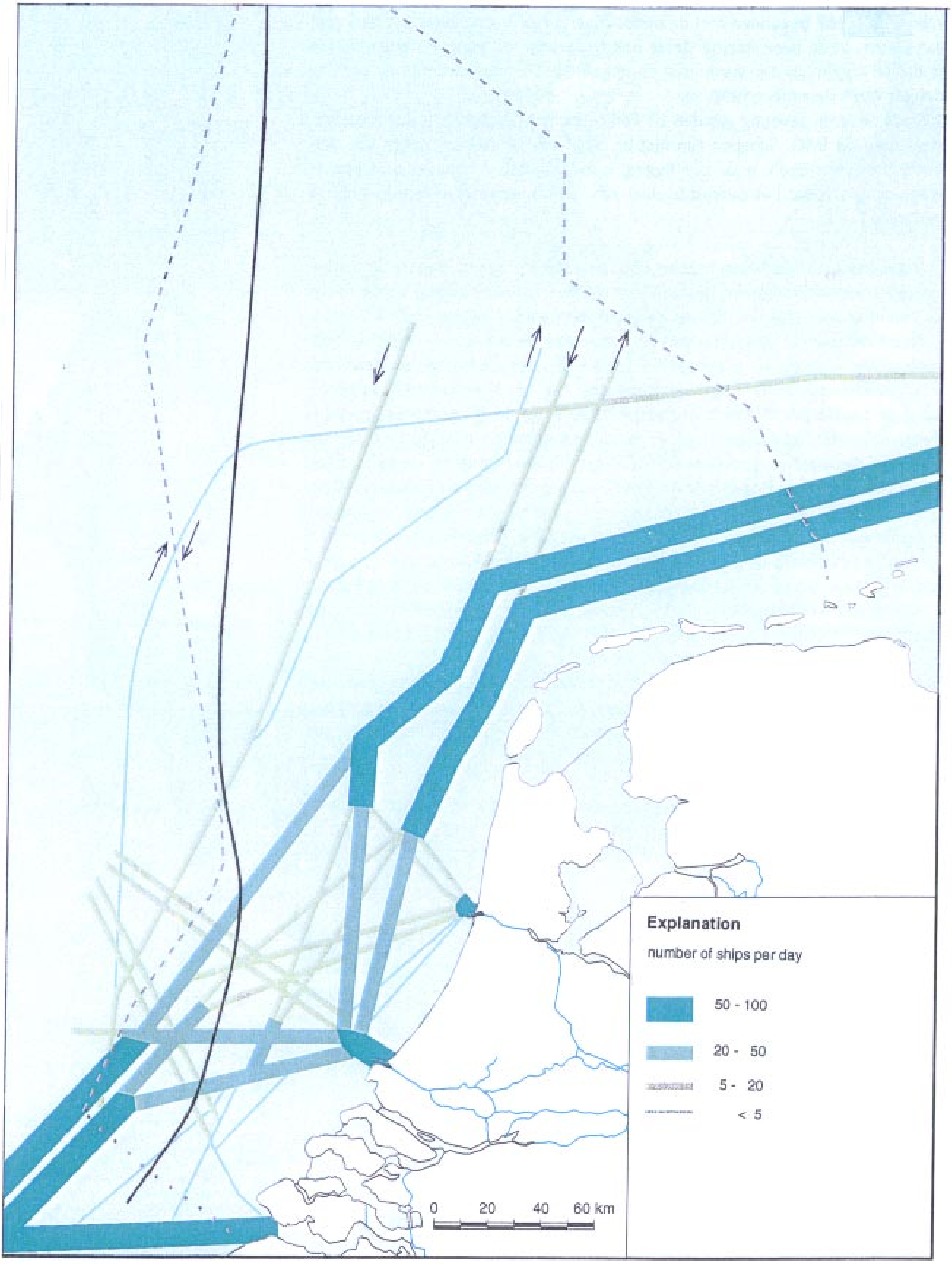
Figure 2.1: **The NorFra pipeline route in the Dutch sector of the North Sea, including the shipping lanes crossed (source map ICONA, 1992).**



3 Description of the influenced area

3.1 North Sea policy - environmental and fishery issues

In the "Nota Harmonisatie Noordzeebeleid - Noordzeebrief 1991 / Voortgangsrapportage Actieprogramma en Noordzeeactieplan" (Note Harmonization North Sea Policy - North Sea Letter 1991 / Progress Report Action Programme and North Sea Action Plan) (Min. Verkeer en Waterstaat, 1990 en 1991) it is indicated different levels of protection of the North Sea.

- A general level of protection of the whole of the North Sea.
- A special level of protection for environmental zones
- A specific level of protection for certain areas within the environmental zone.

The "Watersysteemplan" (Water system Plan North Sea) (Rikjkswaterstaat, 1992) describes the general objective for the North Sea policy as follows: "The evolution of the quality of the North Sea water system to such a level that a lasting conservation and development of ecological values of the North Sea is stimulated and maintained, taking into account the way in which society wishes to make use of the North Sea"

An instrument in pursuing this objective is the protection of certain areas. The environmental zones (fig. 3.4), the whole of the coastal zone up to 20 m below NAP and the Friese Front and the Klaverbank area, have been given a special level of protection.

The planned route of the pipeline will cross the Klaverbank, one of the areas belonging to the environment zone. In the available literature no further restrictions are given with respect to the laying and use of pipelines in this area.

Although it is not implemented in the policy at present, it should be noted that in a study of the possible establishment of protected areas in the North Sea (Bergman et al., 1991) the Klaverbank was put forward as one of the protected areas. It was proposed to prohibit fisheries and the extraction of gravel and to prevent oil containing discharges from offshore mining installations as much as possible in this area. If necessary, additional measures could be considered concerning activities that might have effects on this area. The laying of pipelines is one of these activities.

Furthermore it can be noted that in the elaboration of the nature policy at national level for the period 1990-2018 (Min. Landbouw, Natuurbeheer en Visserij, 1995), it is being considered to assign one or more areas of investigation on a European level in the North Sea. Objective of these areas is to investigate the effects of the prohibition of fisheries and different soil-related activities on the ecosystem. Afterwards, a decision can be made with regard to the desirability of the establishment of permanently closed areas, the prohibition of certain activities and the desired extent in relation to the striving for natural systems.

However, in order to establish protected zones, closed for fisheries, agreement has to be reached at Community level (EU). No decisions are expected at short notice in this respect (information Ministry of Agriculture, Nature Management and Fisheries).

The policy for Dutch offshore fishing is determined to an important extent by the fishery policy of the European Union, the so-called Common Fishery Policy (CFP). The EU-fishery policy includes different regulations. By means of TACs (Total Allowance Catch), the quota policy and technical measures it is tried to maintain the fish stocks. Separate directives have been decided upon the 12-miles zone (outside the scope of this study), because this zone is also of importance as a spawning and nursery area for many fish species. The EU also has concluded a large number of fishery-agreements, thus creating or maintaining catching facilities for EU member states in the waters of non-member countries.

In the "Structuurnota Zee - en kustvisserij" (Min. Landbouw, Natuurbeheer en Visserij, 1993) the national government's policy with regard to fisheries up to the year 2003 is set forth. The general objective of the fishery policy is: "To promote well-considered fishing and a balanced exploitation of the fishstocks". Restrictions with regard to the laying and the use of pipelines in relation to fisheries are not mentioned in the note.

To sum up, the planned route of the NorFra pipeline crosses the Klaverbank, one of the areas belonging to the environment zone. Although the Klaverbank is an area with a special level of protection, no restrictions with respect to the laying and use of offshore pipelines are presently implemented.

3.2 Physical (abiotic) environment

The abiotic environment in this context includes: climate, hydrodynamic- and morphodynamic conditions.

3.2.1 Hydrodynamics

The North Sea is a tidal basin with a complex hydrodynamic pattern induced by the interaction of three tidal waves.

These tidal waves create a complex pattern of net sand and water transport. Tidal transport vectors alternate between north-east and south-west, and the residual velocity is to the north-east. As a result effluents and fine materials (e.g. mud, organic matter) are moved along the coast of the Netherlands and Germany to the central part of the North Sea, at an average speed of some 0.05 $m.s^{-1}$, under calm weather conditions.

Through the Channel and from the North Atlantic ocean, water flows into the North Sea, whereas the outflow of North Sea water is concentrated along the eastern side of the gap between Norway and Shetland. Ocean water is forced into the North Sea by the predominant westerly winds pushing the water in the North Atlantic towards NW Europe. The tidal wave that enters the North Sea from the North and the South, moving through the North Sea in an anticlockwise direction, and also by density differences that are mainly caused by the inflow of fresh water from the coasts, and low-salinity water from the Baltic add to this effect. Most of the fresh water comes from rivers that flow into the southern North Sea, forming low-salinity coastal water moving towards the Skagerrak.

One of the strongest tidal currents of the North sea occurs outside the Dutch coast. The normal direction is SW to NE on flood and reverses on ebb tide.

3.2.2 Morphodynamics

Statoil has produced a geotechnical survey of the pipeline corridor (The report: "Geotechnical design parameters" Statoil 1996). A summing up of the morphodynamic situation is presented on the fig. 3.1.

Pipe embedment along the route is shown in fig. 3.2.

In the sandwave area (from approx KP591 south) the sea bed will be pre-sweeped on the sandwave tops, mainly to avoid the pipe to becom overstresses (see fig. 3.3).

The final position for the pipeline on the seabed will be determined in order to:

- keep the stress levels within the allowable limits
- ensure the pipeline stability under the environmental loads
- avoid free spans and overstresses to occur due to medium and long term sandwave migration

3.3 Biotic environment

The documentation on the biotic environment, fish resources and fishery in particular is produced by Oranjewoud (NorFra Pipeline: Documentation on fishery, Oranjewoud aug. 1996).

Areas of special environmental importance along the proposed route of the NorFra pipeline in the Dutch part of the continental shelf are described below.

3.3.1 Description of the influenced area

The deep sedimentation zone

In the northern part of the North Sea a deep sedimentation zone is present (north of 54^{o}N with the exception of the Doggersbank). In general the depth amounts up to more than 40 m. The bottom consists of silt and fine sand. This situation, being more stable compared to the other zones (including a lower flow rate, a constant temperature and stratification of the water column in summer), allows a relatively high diversity of the macrozoobenthos. The northern part of the North Sea (north of the DCS) is therefor considered as an important spawning area for the Herring among others.

The Klaverbank

The Klaverbank area is a unique part of the Dutch Continental Shelf (DCS) because it is the only area where coarse sand, gravel and large stones can be found in considerable quantities. A rich bottom fauna has developed here, part of which is formed by species which live sedentary on the rocks. However, in the major part of the Dutch sector these species do not occur. Coarse sand can be a suitable substrate for the deposition of eggs by the Herring. Nowadays the herring does not spawn here.

Figure 3.1: Environmentally important areas in the Dutch sector of the North Sea, including the composition of the sediment (ICONA, 1992)

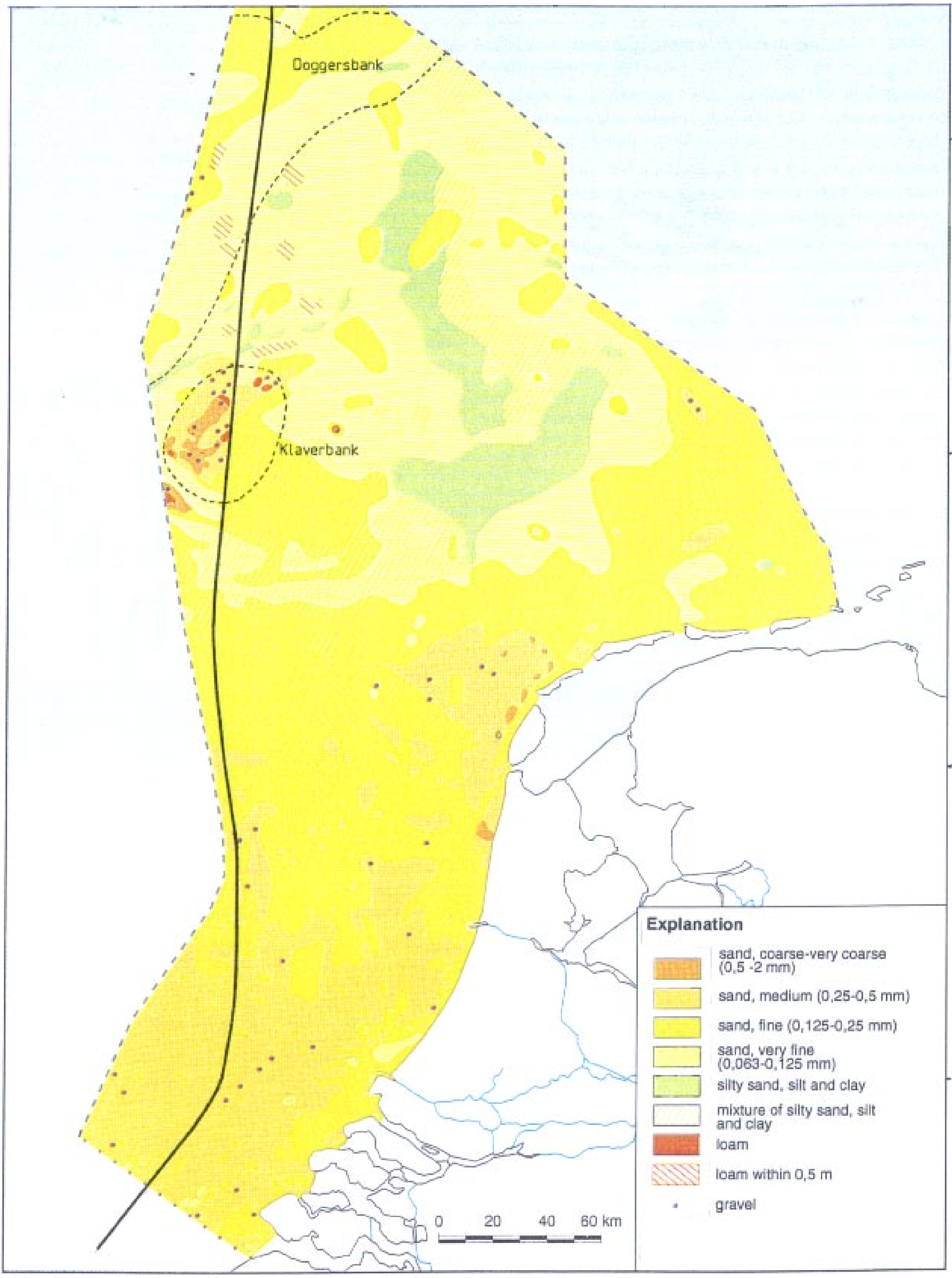
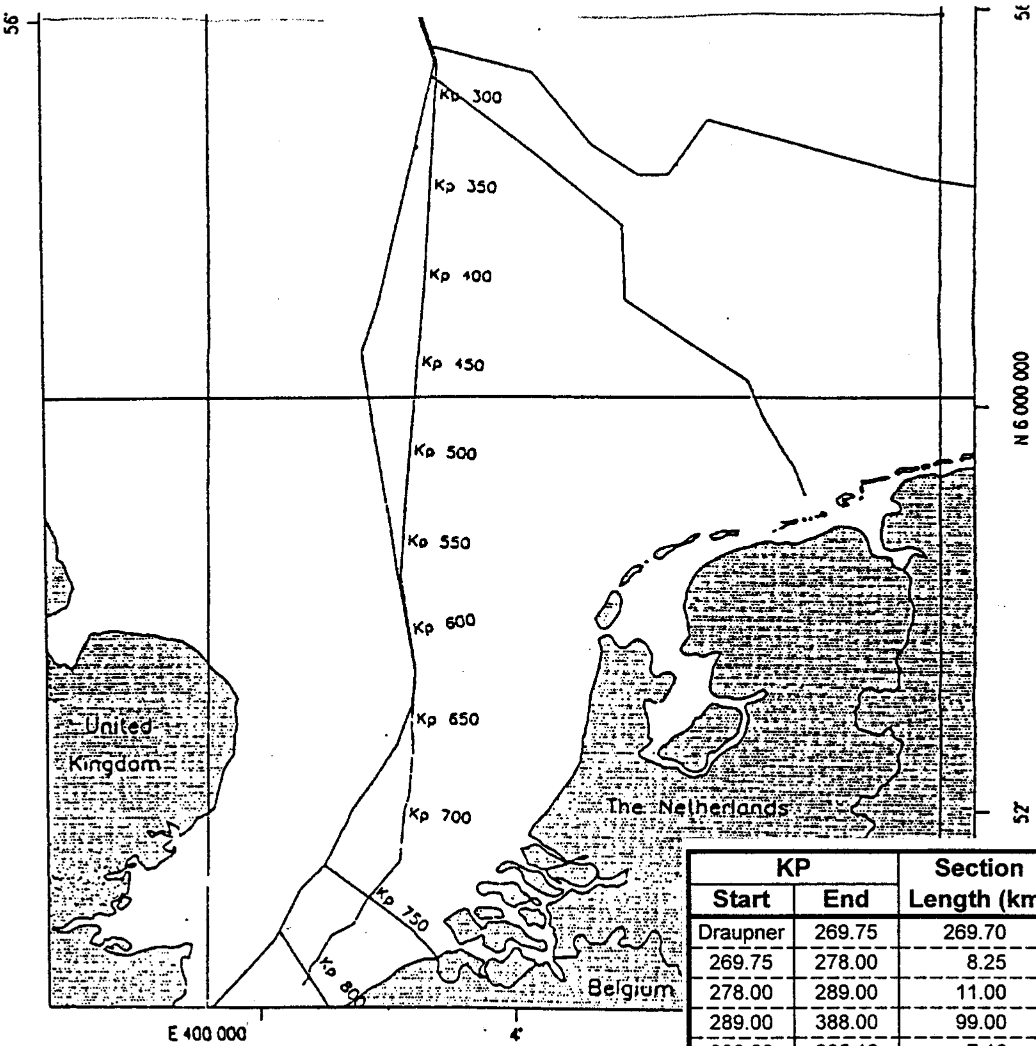


Figure 3.2: Pipe embedment/pipeline route (KP)



KP		Section	Required Pipe
Start	End	Length (km)	Lowering [1]
Draupner	269.75	269.70	None
269.75	278.00	8.25	0.7m
278.00	289.00	11.00	0.9m
289.00	388.00	99.00	1.3m
388.00	395.16	7.16	0.7m
395.16	396.21	1.05	1.8m
396.21	427.31	31.10	0.7m
427.31	453.40	26.09	None
453.40	637.00	183.60	0.7m
637.00	641.60	4.60	None
641.60	707.26	65.66	0.7m
707.26	712.41	5.15	36.1m [2]
712.41	776.10	63.69	0.7m
776.10	778.08	1.98	None
778.08	780.66	2.58	0.7m
780.66	785.00	4.34	None
785.00	793.56	8.56	0.7m
793.56	798.55	4.99	2.3m
798.55	804.00	5.45	0.7m
804.00	810.00	6.00	1.3m
810.00	814.00	4.00	2.0m
814.00	817.00	3.00	1.3m

NOTES 1. Measured as Bottom of Pipe relative to natural seabed level
2. Measured as Bottom of Pipe relative to Mean Sea Level (MSL)

Figur 3.3: Illustration of pre-sweeping actions

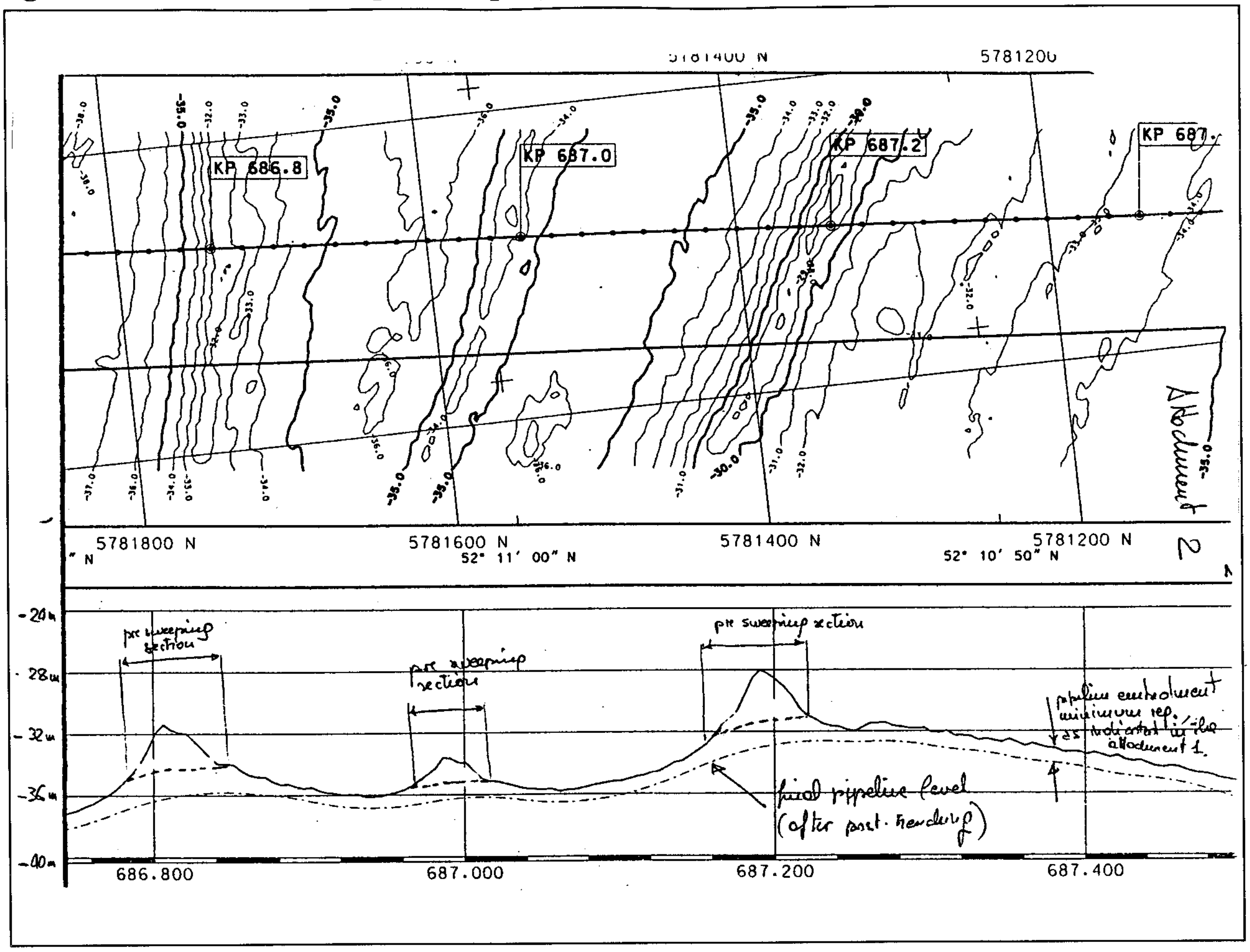
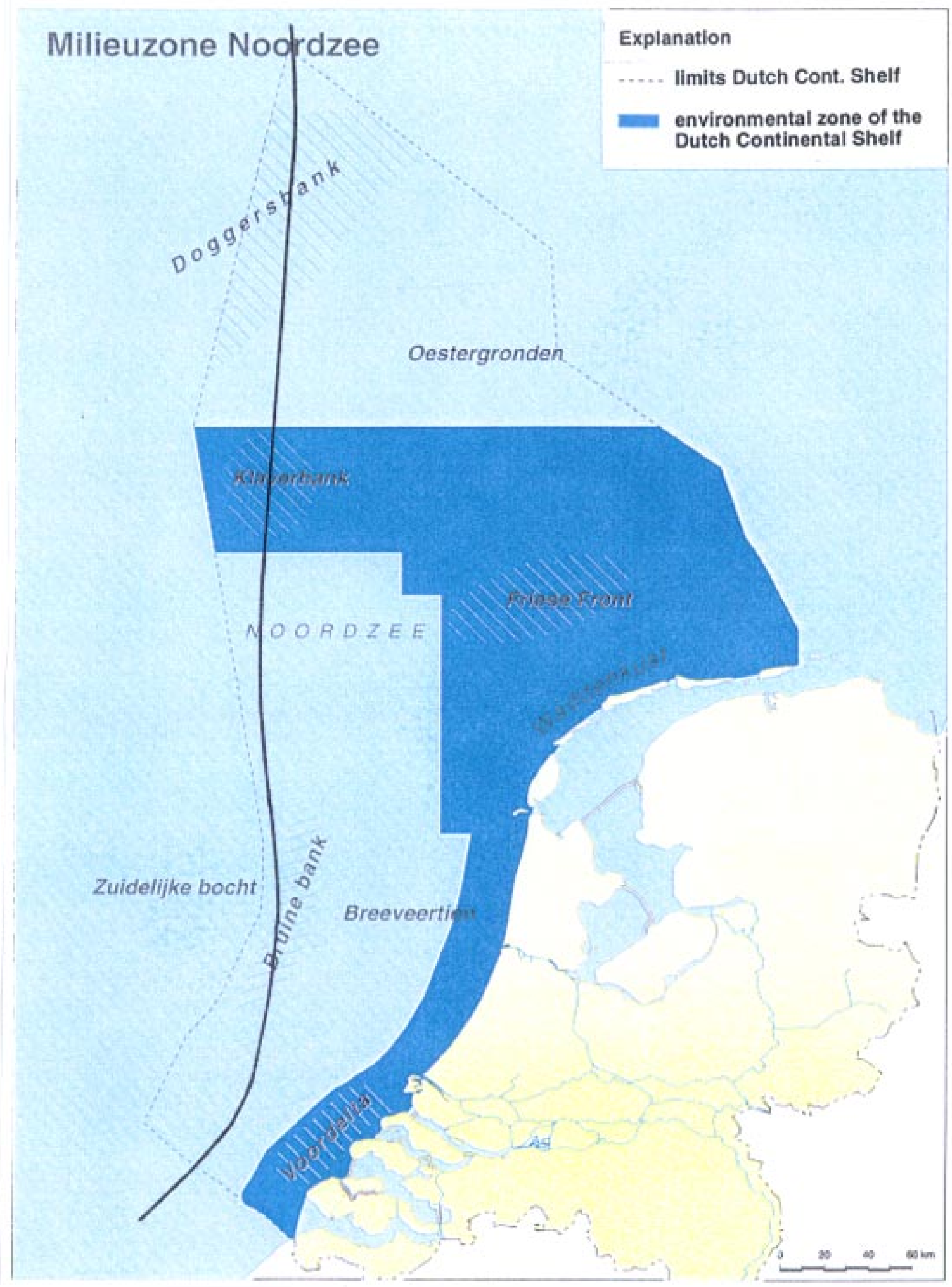


Figure 3.4: The environmental zone in the Dutch sector of the North Sea, according to the "Watersysteemplan Noordzee" (Water system Plan North Sea) (Rijkswaterstaat, 1992)



The shallow erosion zone

The Doggerbank forms a shallow erosion zone. In the southern part of the North Sea also shallow erosion zones occur. In general this part of the DCS has a depth of less than 20 m (figure 1). The bottom is sandy. The area is a spawning zone for Sprat, Plaice and Herring.

3.3.2 Fish resources

More than 200 fish species have been recorded from the North Sea. Commercial species whose adults occur in large numbers on the continental shelf are Sprat, Cod, Whiting, Grey Gurnard, Scad, Mackerel, Dab and Plaice. In view of the importance to Dutch fisheries Sole and Herring are also mentioned. The biology of these species is very well known.

Because of the commercial importance of fisheries, large-scale sampling programmes aiming at pelagic (free-floating) eggs, young and adult fish are carried out on an annual basis in the North Sea. The sampling programmes are coordinated by the ICES (International Council for the Exploration of the Sea).

The results of these sampling programmes show that the spawning stocks of most of the fish species in the area of importance for the Netherlands were above the "safe biological minimum" between 1985 and 1992. Exceptions are the stocks of Herring (temporary closing of fishery) and Cod.

All species mentioned migrate in the course of the year. The pelagic species, which spend their life swimming in the watercolumn (Sprat, Scad, Mackerel, Herring), migrate the most because their spawning and foraging areas are often far apart. The demersal species (living on or near the bottom) also migrate, but not over large distance. In winter, when Cod and Plaice are ready to spawn, they migrate into the center of the southern part of the North Sea to spawn in January - February. Sole migrate inshore when their spawning period (April) is nearing. The Grey Gurnard can hardly be found on the continental shelf in early spring, they are on the north-western side of the Doggerbank in winter and migrate into the direction of the German Bight in summer. Scad and Mackerel are very rare in the North Sea in winter, they spend the winter in Atlantic waters.

Differences in distribution between different age-groups of the same species also occur. Older animals generally live in deeper water than young specimens of the same species.

The distribution of most species in the North Sea can vary significantly between years and also within one season. The distribution of many species is also very "patchy", which means large numbers of a species may occur in a very small area while a few hundred metres away nothing is found.

Concentrations of pelagic fish are found in the Friese Front area. Demersal fish is relatively abundant in this area also due to the high biomass of zoobenthos.

Except for the Herring all species mentioned spawn on the continental shelf, especially south of 54°N. The earliest spawners are Cod and Plaice (January - March), Dab, Whiting and Sprat follow

(February - June) and then Sole and Gurnard (March - June), Mackerel and Scad (May - July). All of these species spawn pelagic eggs, the spawning grounds of these species are not strictly defined.

The North Sea Herring stock comprises several populations, each with their own spawning period and spawning area. One population spawns near the northern English and Scottish coasts in autumn, and another spawns in the English Channel in winter. Herring does not spawn on the Dutch continental shelf nowadays. These species deposits their eggs on the bottom consisting of coarse sand and gravel, which are scarce on the continental shelf. In the past (before the seventies), when stocks were much higher, the Herring used to spawn in the Doggerbank and the Klaverbank area. This was a herring population called "Bank-Herring", that has become extinct now.

The larves of Sole, Place, Dab, Cod and Herring are passively carried by the currents into the shallow coastal waters and the Wadden Sea during their early larval stages. These areas are referred to as "nursery areas". The species spend the first two years of their lives close to the shore. Afterwards they gradually migrate into deeper water (Sole, Plaice, Dab, Cod) or form large migrating shoals (Herring).

It is hard to predict how the commercially important fish stocks will develop. Stock sizes nowadays strongly depend on the reproductive success a few years earlier because the age structure of the populations of exploited species is not very wellbalanced anymore, now that fisheries take most of the older specimens. Factors determining the reproductive success are not well known, environmental factors are assumed to play an important part during the first year of life.

3.4 Socio-economic activities and fisheries

In view of the limited period of time available, the description of the fishing fleet is based on information already published (ICONA, 1992; Min. Landbouw, Natuurbeheer en Visserij, 1993) and a limited update with data collected by the "Rikjsinstituut voor Visserijkundig Onderzoek" (RIVO).

Compared to other European countries the Netherlands have a relatively small fleet with relatively large vessels. By the end of 1991 the fishing fleet consisted of 494 cutters, 13 freezer trawlers and 148 shellfish vessels. Within the group of cutters a further distinction can be made based on the h.p. (horse power) of the ships. Depending on the h.p. the ships are fishing for different species of fish (e.g. flatfish, roundfish) and shrimps. The Dutch trawlers, specialised in the catching of pelagic fish which are processed and frozen on board, mainly have their fishing grounds outside the North Sea.

Two main types of fishery in the North Sea can be distinguished: pelagic fishery, for which large floating trawls are used to catch pelagic species such as Herring, Mackerel and Scad, and demersal fishery, aimed at species living at or near the bottom. The beamtrawl fishery, a form of demersal fishery, is the most important fishery in the Netherlands. The Dutch fleet also comprises the main part of the European beamtrawl fleet. A minority of the demersal fishery fleet uses a bottom trawl, a net held open by two boards and pulled along the bottom. This gear is predominantly deployed in the fishery for Gadoids in the southern part of the North Sea in the first quarter of the year. Fishing vessels from other countries probably use this method in the Dutch sector of the North as well. Other methods (seines, standing and drifting gill nets) are hardly used anymore by the Dutch fleet.

A beamtrawl is a cone-shaped net, of which the upper front end is fixed to a beam supported by two gliders, in the lower side of the mount of the net tickler chains are fastened to scare the fish out of the sediment. The net is pulled over the sea floor at a speed of about 10 km/h depending on the size of the beam and the engine power of the vessels.

In table 3.1 an overview is given of the fishing effort of the beamtrawl fishery as related to the total fishery effort of the Dutch fleet. The table shows that the beamtrawl fishery has become more and more important since 1988. The total fishing effort by the Dutch fleet in the period 1988-1995 shows some yearly fluctuations: between 80,000,000 and 91,200,000 so-called "horse power days".

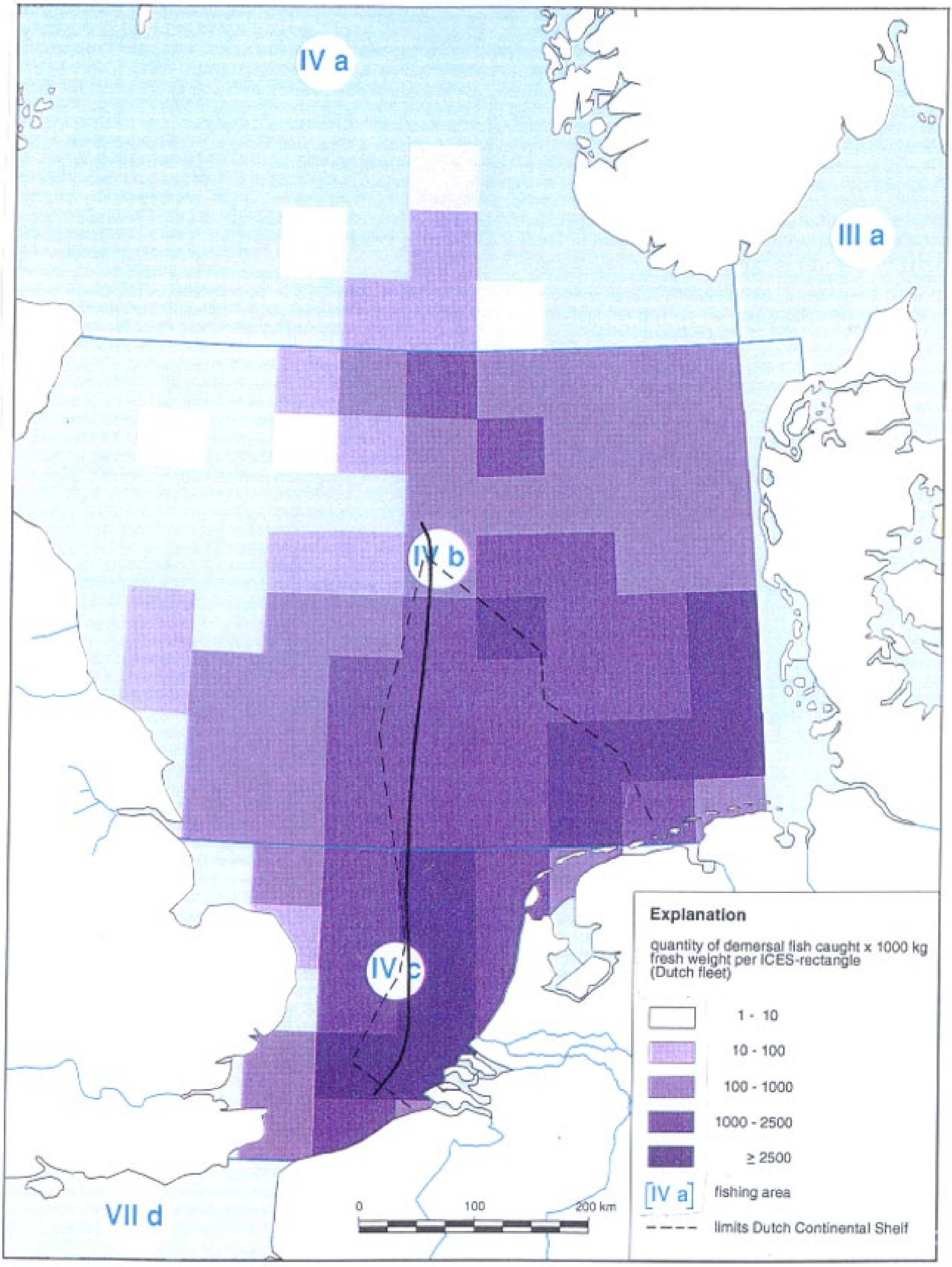
Table 3.1: Fishing effort of the beamtrawl as related to the total fishery effort of the Dutch fleet in 1988 - 1995

Year	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Percentage of total fishing effort	83,7	83,2	86,2	86,9	88	89,1	90,2	89,4

Figure 3.5 shows the spatial distribution of the demersal fish caught by the Dutch fleet in 1990. According to the RIVO the distribution has not changed much since.

As figure 3.5 shows the areas crossed by the pipeline are areas in which relatively high quantities of demersal fish are caught, especially in the southern half of the Dutch Continental Shelf (DCS). Furthermore, it can be stated that nowadays there are no specific periods during which the beamtrawl fishery takes place, the DCS is being fished during the whole year.

Figure 3.5: Demersal fish caught by the Dutch fleet in 1990 (ICONA, 1992



4 Impact assessment

The presentation of the impact assessment will be structured into:

- Abiotic impacts
- Biotic impacts
- Socio-economic impacts

4.1 Abiotic impact assessment

The abiotic impacts are grouped as follows:

- Emission to air
- Hydrodynamics/morphodynamics/sedimentology and water quality

4.1.1 Emission to air

The main component of natural gas is methane. Since natural gas is cleaned in the production installations before it is transported, the product is neither polluting, nor toxic, nor corrosive. Emissions of methane may contribute to increase the greenhouse effect. However, no regular emissions will take place during operation. Under accidental conditions, a gas release could happen caused by an external impact damaging the pipeline. The probability of occurrence of such an event is very low. During construction time, impact on air quality may occur resulting from the combustion of fuel and gasoil.

The most important sources of air pollution will be the exhaustgases of motors and equipment of dredgers and ships. Fuel consumption of the vessels during the construction-phase in Dutch sector is estimated to 10.000 - 15.000 tonnes diesel, which is estimated to cause an emission of 700 - 1.050 tons of NO_X, 40 - 60 tons of SO_2 and 32.000 - 48.000 tons of CO_2. Generally NO_X emission levels from ships are relatively high compared to many other emission sources, hovever the emission levels indicated above for the NorFra project does not deviate compared to emission levels from similar pipelaying projects

4.1.2 Hydrodynamics

The tidal waves create a complex pattern of net sand and water transport. The pipeline will be laid on the sea bottom after a pre-sweeping.

Scours can occur underneath the pipeline. This means that:

- the sea bed material underneath the pipeline can be eroded
- the flow pattern near the bottom can be obstructed, resulting in a change in flow pattern. Whether the bottom will react on the change of the flow pattern due to the obstruction, will depend on the characteristics of the bottom material.

Due to scour, the morphological structures of sandwaves and ripples in the immediate vicinity of the pipeline, will be interrupted. The extent of this phenomena cannot be estimated properly, but is eventually expected to be of a local character.

4.1.3 Morphodynamics, sedimentology and water quality

The morphological changes expected during the lifetime of the pipeline have been taken into account during the design phase and will still be considered during the operation of the pipeline.

Impact on water quality may primarily be related to pre-sweeping and excavation of the pipeline trench, and post laying trenching of the pipeline, and are thus limited to the construction period. During commissioning the pipeline will be filled with water. Water filling will take place in Dunkerque in France, and the water will be discharged in the Norwegian part of the North Sea. No discharge will take place in Dutch waters. There will be no impact on water quality resulting from the operation of the pipeline.

During construction different types of impacts on water quality may possibly occur:

- Increase in turbidity caused by intervention works (pre-sweeping, trenching, etc.)
- Release of pollutants deposited in the sediments
- Accidental pollution from construction vessels.

Geophysical and geotechnical surveys of the sediments carried out along the pipeline route have revealed that there is sand in the upper layers (2-10 m), with underlying clay, along most of the route.

As pre-sweeping of the trench prior to pipelaying will only imply excavation of sand at the top of the sandwaves, and also trenching primarily will take place in the upper sand layers, only very limited and local increase in turbidity may be expected as a result of these activities.

Measurements of turbidity carried out during the construction of Europipe to Germany, where 3.2 million m^3 sand and clay was dredged and subsequently backfilled (only sand used for backfilling), showed no or only insignificant increase in mean turbidity as a result of the construction activities. Only a very local increase of 6-12% in turbidity was observed in the immediate vicinity of an area being dredged. Generally it was concluded that the changes in turbidity was mainly dependent on the weather conditions (wind, waves, currents).

With respect to accidental pollution from the construction vessels, these might potentially include accidental oil spills (fuel oil and hydraulic oils). However, the risk of such accidental spills are limited (based on previous experiences). Preventive measures will be taken in order to reduce the risk of accidental pollution (ref. MARPOL).

No permanent impacts on the water quality are expected during the operation phase, taking into account the neutral chemical covering of the pipeline.

The possible effects on the abiotic environment are summarised in Table 4.1. The possible effects of these phenomena on the biotic environment are described in Table 4.2.

Table 4.1: Activities associated with the construction of a pipeline and the possible effects on the abiotic environment

Activity	Possible effects on the abiotic environment	Type effect
Trenching	- Raise in suspended matter content - Raise in turbidity - Release of nutrients - Increase in sedimentation - Mixing of bottom layers	- temporary - temporary - temporary - temporary - temporary
Pipe laying and trenching	- Shipping movements - Noise production	- temporary - temporary
Use of the pipeline	- Pipe surface functions as a potential substrates for organism if the pipeline is not digged in	- permanent

4.2 Biotic impact assessment

The environmental impact assessment of the biotic environment is based on the report produced by Oranjewoud.

4.2.1 Impacts on benthic communities and fishresources

The laying of the pipeline by trenching and anchor mounds are expected to be the "major" activities/aspects that may cause effects on fish. The extent to which the effects of trenching of the pipeline occur, may depend on the method used. Trenching will most probably take place by a combination of hydraulic jetting and ploughing.

As most of the impacts on fish are the result of disturbances (effects) on both the abiotic and biotic environment, the relevant possible effects on these components are summarised in table 4.2.

Table 4.2: Possible abiotic and biotic effects relevant for fish

Phenomenon	Possible effects on the abiotic environment	Possible effects on biotic components related to fish	Possible effects on fish
Post-trenching by means of hydraulic jetting	Mixing and disturbance of bottom layers	Mortality of benthic fauna (zoobenthos)	-Food becomes available (shortterm effect) - Temporary loss of foraging area (local effect) - Inhibition oxygen uptake (shortterm effect) Mortality of demersal eggs due to burial
Anchor mounds	Disturbance of bottom layers	Mortality of bottomfaunaspecies (very local)	Loss of foraging area (very local)
Presence pipeline on the bottom of the sea	New type of substrate available in the area	Diversity of zoobenthos species increases	- New foraging areas with a different prey composition - Possible local changes in the distribution pattern of fish

The effects on fish mentioned in table 4.2 will be discussed below.

Mixing and disturbance of bottom layers

As a result of jetting or ploughing the bottom layers of the sediment will be disturbed. Most of the zoobenthos present in the trenched zone will probably be damaged. This may cause a temporary raise in the food amount available for fish. Most demersal fish species, foraging mainly on zoobenthos, use their tactile and olfactory senses in locating prey. These species could be attracted by the smell of damaged benthic organisms. The benthic organisms exposed as a result of trenching may serve as food for demersal fish, which would otherwise not have been available (Rijkswaterstaat, 1991). This effect however is temporary and very local, only the width of the trenched zone.

As a result of this mortality the trenched zone will temporarily have a lower biomass of zoobenthos, and thus will be a less suitable foraging area. A study of GKSS Forschungszentrum Geesthacht (1995) on the recovery of the benthic fauna in most sandy sediments after the laying of Europipe showed that one year after the laying of the pipeline the disturbed areas were already colonised by several species. Three opportunistic species of Polychaetes (worms) were most abundant. It should be noticed however, that biomass figures are not mentioned in this study. Studies of Oranjewoud (1991 and 1992) showed that one year after the laying of a drinking water pipeline through the Dutch Wadden Sea, no significant differences in total biomass could be observed between the disturbed zone and the reference zone. However, the biomass and the abundance of the various species (worms and bivalves) still were different. The recovery of bivalves was mostly due to colonisation with juveniles. It should be remarked that depending on the type of sediment and the installation method, the disturbed zone had a width of 10 m at maximum. Van der Veer (1979) mentions that in more dynamic and sandy areas such as gullies recovery will take place within 2-3 years.

The deposition of sediment on their eggs could cause the development rate to decrease or even cause the eggs to die because of the inhibition of oxygen uptake by the eggs.

As stated above a raised suspended matter content may occure in a zone of up to 500 m on both sides of the pipeline. Only in a part of this zone higher sedimentation rates may temporarily occur. In this area egg development can be disturbed. If the effects will actually occur, depends among others on the period during which the trenching will take place and the fact whether eggs are deposited in the pipeline zone or not. On the basis of the available literature more accurate estimates of the effect cannot be made. However, it can be stated that the effect will only be temporarily.

Anchor mounds

Experience from other pipelaying projects have shown that anchor mounds may occur along pipelines. These mounds will cause a relatively small loss of potential foraging area. In view of the fact that these mounds will disappear relatively quickly in sandy sediments (and areas with strong currents) (Statoil experiences and references), the fact that most of the area crossed consists of sandy sediments, and the fact that the area disturbed is relatively small (so that recovery of the benthic fauna can take place in a short time) it is expected that this effect will only be of minor importance.

Conclusion

Generally the main conclusion is that the laying of the NorFra pipeline may cause only limited effects on (potential) foraging and spawning areas for fish. As these effects will only occur in a relatively restricted zone, the effects on a population level are expected to be negligible. The effect will be the largest on the level of the individual organisms (fish). For smaller areas with special values such as the Klaverbank, the impact may be relatively larger.

4.3 Socio-economic impacts

The third party activities that might be affected by the project are the following:

- the sea-fishery
- ship traffic
- the existing pipelines and cables

4.3.1 Fishery

Generally, three types of impacts on fishery activities may be envisaged:

- Presence of construction vessels may temporarily exclude fishery activities in the construction area
- Intervention works and anchors may temporarily disturb the sea bottom

- The presence of the pipeline on the seabed may represent an obstacle to fishery activities, in particular trawling, during the operation phase

a. Temporary impact related to the construction activities

The pipeline will be laid outside the 12 mile zone, and will thereby also avoid the most important spawning and catching area for sole. The fishing areas between the outer sandbanks will be crossed. Pre-sweeping and excavation of the pipeline trench will only take place at the top of the sandwaves, and because of the dynamic nature of this habitat, regeneration will be fast and no significant indirect impact of fishery is expected.

The pipelaying vessel will use anchors for positioning, and during pipelaying an area 6-8 km^2 will at any time be occupied by the pipelaying vessel and its anchor wires. No fishing activity can take place within this area during pipelaying. However, as the pipeline vessel is moving ca. 3 km per day, the impact on fishery activities through loss of access to fishing grounds is temporary and very limited.

As further discussed below, large diameter pipelines is in general not expected to be an obstacle for trawling, neither by use of otter trawls nor beam trawls. The possibility that a beam trawl might get stuck behind the pipeline in the period between pipelaying and trenching, can not be completely excluded, if major free spans should temporarily occur and if trawling across the pipeline takes place at a narrow angle during this period. The potential for having such temporary free spans will be further investigated in the detailed engineering.

Experience from other pipelaying projects have shown that anchor mounds may occur along pipelines, and it has been claimed that such anchor mounds represent a potential risk of disturbance to trawls. Surveys along two pipelines in the Norwegian sector documented anchor mounds 200-1400 m from the pipeline. On sand bottom and in areas with strong currents, the anchor mounds will disappear relatively quickly after pipelaying, whereas they may remain longer in areas where the bottom sediments are comprised by clay. Anchor mounds of 0.5 m were observed on medium stiff clay one year after pipelaying. This corresponds to observations made in British waters. As most of the bottom along the pipeline route through the dutch sector consists of sand, potential problems related to anchor mounds are considered to be insignificant.

b. Impact related to physical presence of the pipeline

The pipeline route crosses areas which are intensively fished. Especially in the IVa-area (fig. 3.5) a lot of demersal fish is caught. The depth in this area is mainly less than 30 m, and therefore most of the pipeline will be post-trenched for stability reasons in this section. This will reduce the risk of interference. In deeper areas (IVb-area) the quantity of fish caught is less, but still relatively high. In these parts the pipeline will not be buried.

Most interactions between the proposed pipeline and fisheries are expected from the beamtrawl fishery, the most important type of fishing by the Dutch fleet. Large parts of the Dutch sector of the North Sea are fished by beamtrawlers 2-6 times per year.

In the seventies the engine power of the vessels increased and the beamtrawl equipment became larger and heavier. The front ends of the beamtrawl shoes changed form semi-circular (mended) to pointed, because these were easier to manufacture from heavy material. The result of this was an increasing damage to the coating of pipelines. By the end of the seventies a new type of beamtrawl shoe had been developed, semi-circular again, reducing the forces occurring at collisions with pipelines and preventing hooking of cables and (small diameter) pipelines by the fishing gear (De Groot, 1979). This type of gear is now used by most fishermen, although the unadapted version is still being used by some of them.

On the other side, the offshore pipeline industry learned their lessons from the damage caused. Experiments where made, and this was translated into reinforcing the concrete coating with various types of "weaponing". This was successfully accomplished and the pipelines today can withstand the impact of any fishing gear without damage (De Groot, 1986).

During the operational phase of a pipeline, potential conflicts with fishing activities may relate to how welded joints of pipelines are closed or covered, pipe-dimensions and trawling across the pipeline, free spans and route alignment of the pipeline. Welded pipeline joints were earlier considered to be potential catches for trawling gear passing over the pipeline. Also free spans have been considered a potential risk for trawl doors and gear to be hooked.

Welded pipeline joints have been said to represent a potential risk for damage to fishing gear passing over the joints. It is foreseen that asphalt mastic sheeted with aluminium will be used for covering the welded joints. The aluminium sheeting will be dissolved by the sea water, and the potential problems for damaging gear should therefore be temporary.

TEEs are not expected to be a problem for fishery activities, as they will either be covered by gravel, or trenched.

With respect to pipeline alignment and free spans, reference can be made to trawl tests in both Norwegian, German and Dutch waters. Statoil has financed trawl test in Norwegian and German waters, where crossing of pipelines in different angles with otter trawls were studied by the Norwegian Marine Research Institute. The studies concluded that the crossing of pipelines did not represent any danger for the fishing equipment, and no increased gear damage was observed. Crossing at angles less than 30^{o} could lead to temporary disturbance to trawl doors. The trawls and the trawl doors where at all instances stabilised within 10 minutes after crossing. The trawl test along the Zeepipe in Germany concurred with the tests in Norwegian waters, and documented furthermore that even crossing of free spans up to 80 cm high, did not cause any significant problems for the trawling activities.

In Dutch waters beam trawls are the most commonly used fishing gear, and the results from the Norwegian and German trawl-test using otter trawls may therefore not be directly applicable. However, comprehensive studies made in the Netherlands on beam trawl - pipeline interactions have concluded that crossing of pipelines by beam trawls represent no significant obstacle. The Dutch studies include both numerical simulations, model tests and field tests. Parameters considered include among others the size of the beam trawlers (vessels with engine power of 500-4000 hp), pipeline diameter (16" and larger), geometry of beam trawl shoe and location of towing point.

4.3.2 Shiptraffic (navigation)

The pipeline will cross shipping lanes, where special measures may be required. These measures will be worked out together with relevant authorities.

4.3.3 Existing pipelines and cables

The NorFra pipeline will cross two existing pipelines and these existing cables (ref. table 2.1). If special measure are required, they will be worked out together with relevant authorities.

5 Mitigation measures

5.1 Air and water quality

Despite the probability of a gas release along the pipeline route is extremely low, this risk will also be minimised by adequate measures, as follows:

- a leak detection system will be installed
- an inspection programme will take place at regular time basis
- a procedure for depressurisation will be applied
- a possibility to shut down the gas transport is also foreseen

Use of low sulphur fuel (0,2 %) is generally foreseen during construction.

5.2 Morphology

A monitoring programme is planned to take place after pipelaying and during operation in order to establish the real situation of the pipeline. Such programme includes a survey of the pipeline at regular time interval which should identify zones of free-spans and will be the basis to start-up an intervention plan.

5.3 Exological sensitive areas

Klaverbank is defined as an environment sensitive area, particular care should be taken during construction to minimize ecological impacts.

5.4 Accidental pollution

In the framework of each gas transportation project, on behalf of Statoil, an Emergency Preparedness Plan is prepared and maintained in order to manage every emergency situation.

In order to minimise the consequences of an accidental pollution during execution, the emergency preparedness team in charge of applying such plan will be prepared to mobilise the necessary oil spill fighting equipment.

5.5 Fishery and navigation

A guard vessel will be empoied during the construction period, and systems for communication with fishery vessels and other ships will be established in order to prevent any accidental interactions, and a safety zone will be defined. Inspection of the pipeline will take place immediately after pipelaying, and if free spans should eventually occure in the period between pipelaying and trenching, the need for eventually marking the pipeline will be considered in cooperation with the relevant authorities.